



EUROfusion Human Resources Development, Training and Knowledge Management

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IAEA Technical Meeting Fission-Fusion Synergies on Synergies between
Fission-Fusion (*EVT2 103079*)
Vienna/Hybrid | 6-10 June 2022



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EUROfusion in 2022 – A Europe-wide R&D consortium



EUROfusion integrates R&D in fusion science and technology

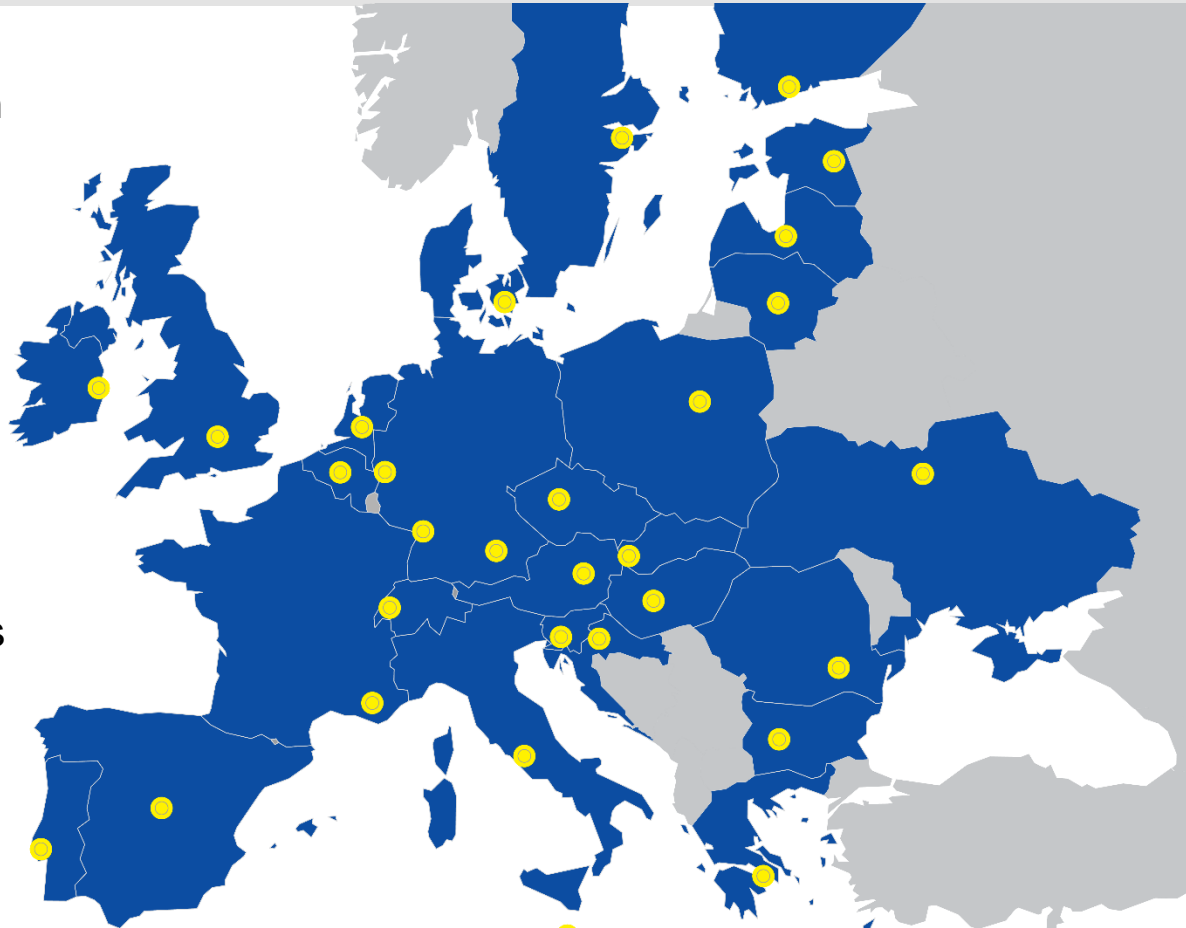
28 Countries

30 Research Institutions

150 Universities

800 MSc and PhD students

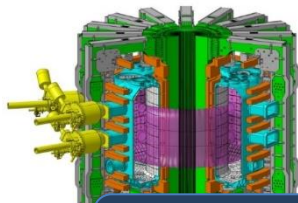
4000 Fusion Researchers & Support Staff



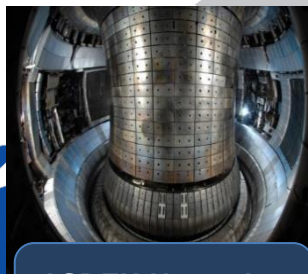
EUROfusion facilitates joint operation of tokamaks



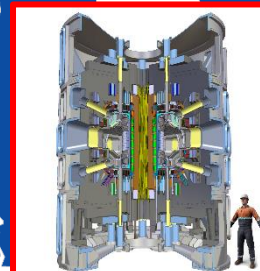
JET
UK



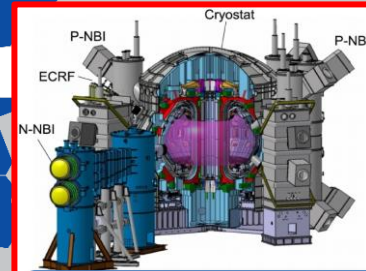
TCV,
Switzerland



ASDEX Upgrade
Germany



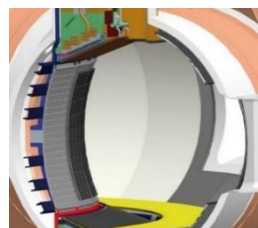
COMPASS Upgrade
Czech Republic
(construction phase)



JT-60SA
Japan
(commissioning phase)



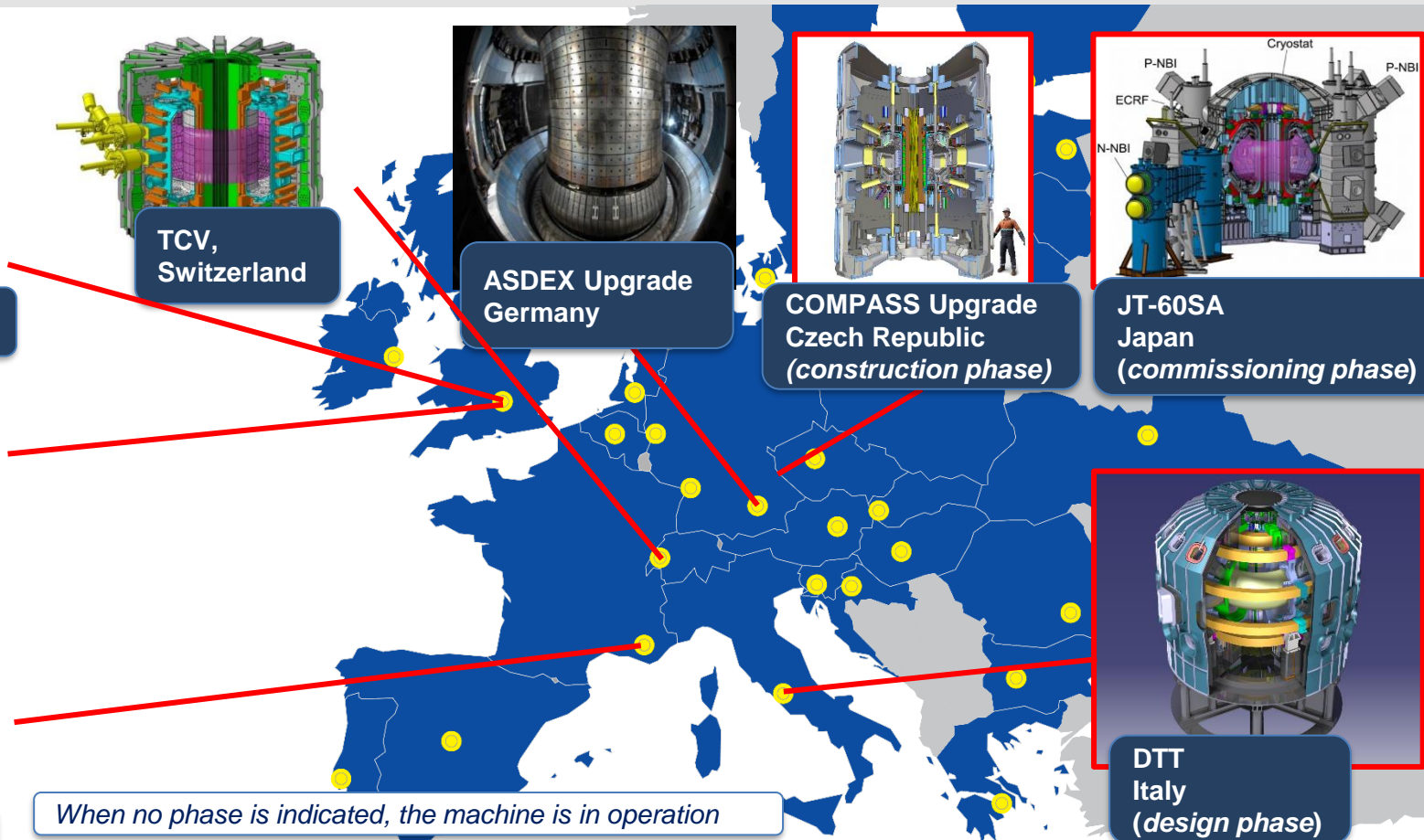
MAST Upgrade
UK



WEST
France

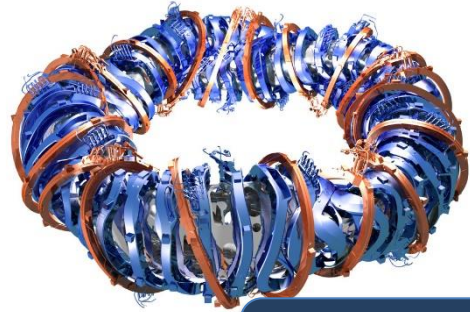


DTT
Italy
(design phase)

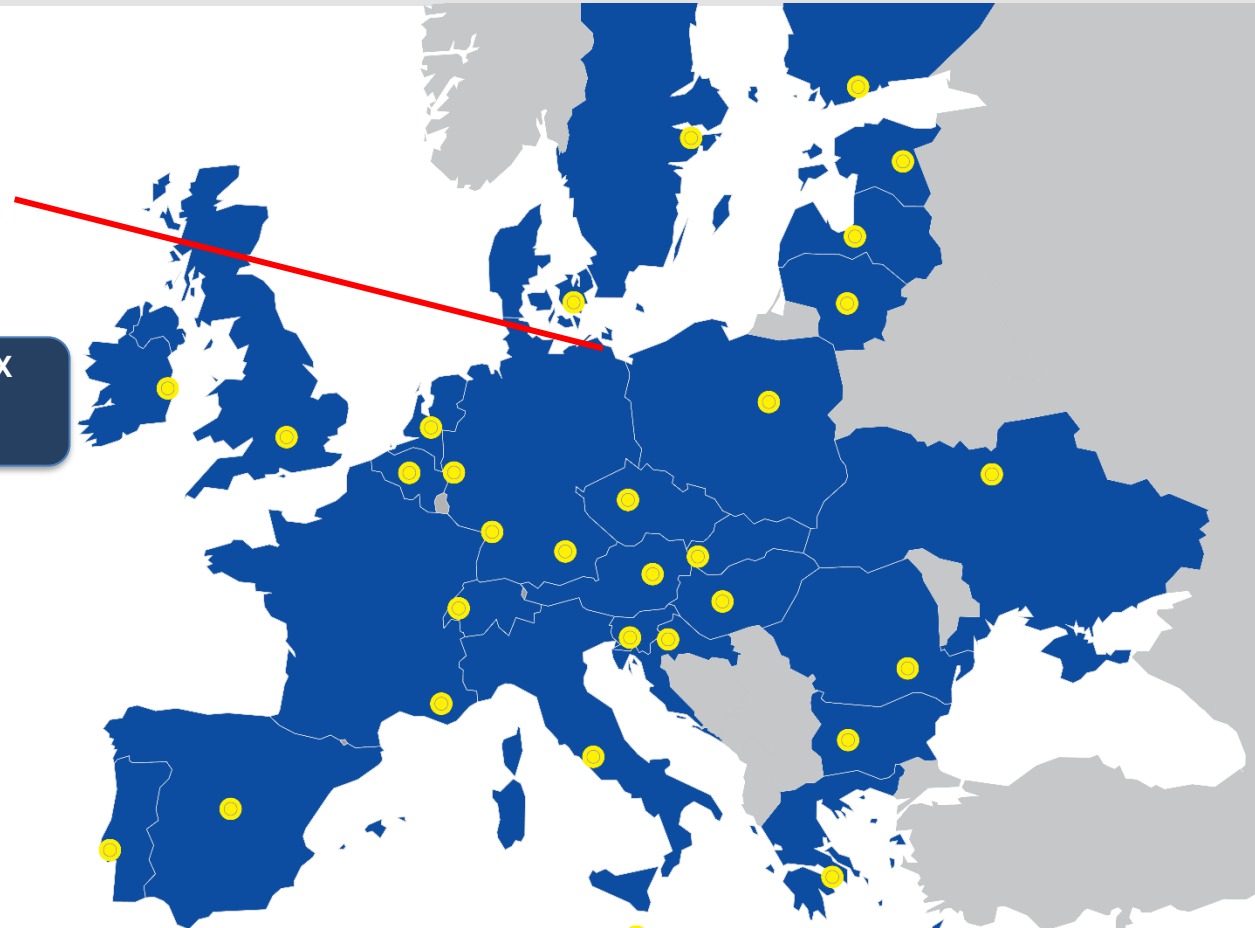


When no phase is indicated, the machine is in operation

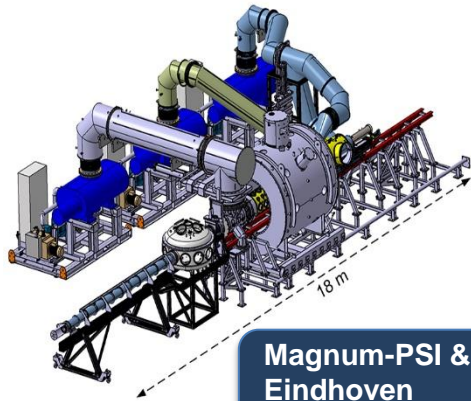
EUROfusion unites the stellarator community



Wendelstein 7-X
Greifswald
Germany



EUROfusion brings joint operation of linear devices

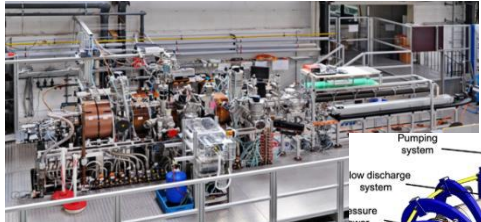
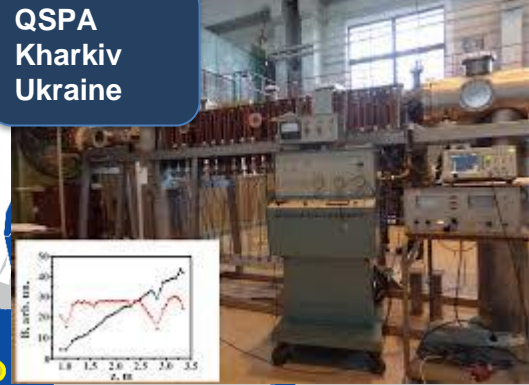


Magnum-PSI & UPP
Eindhoven
Netherlands

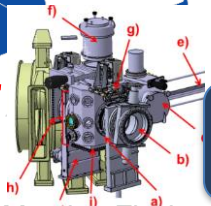
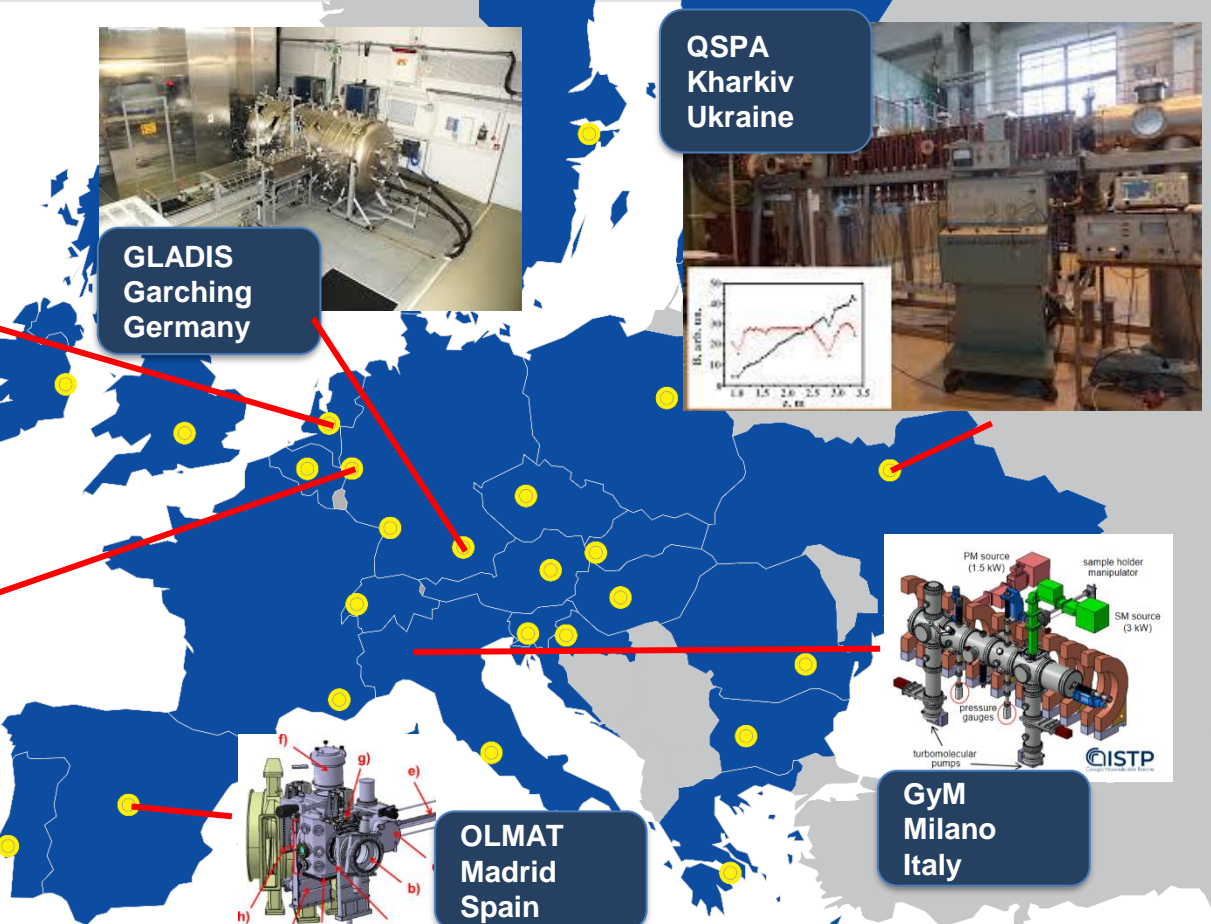
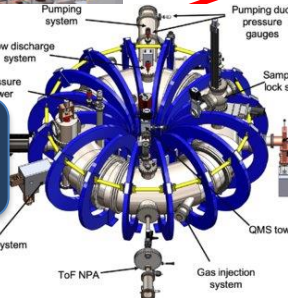


GLADIS
Garching
Germany

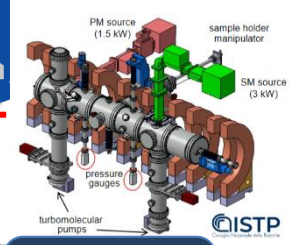
QSPA
Kharkiv
Ukraine



**JULE-PSI, PSI-2
TOMAS** Jülich
Germany

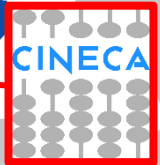
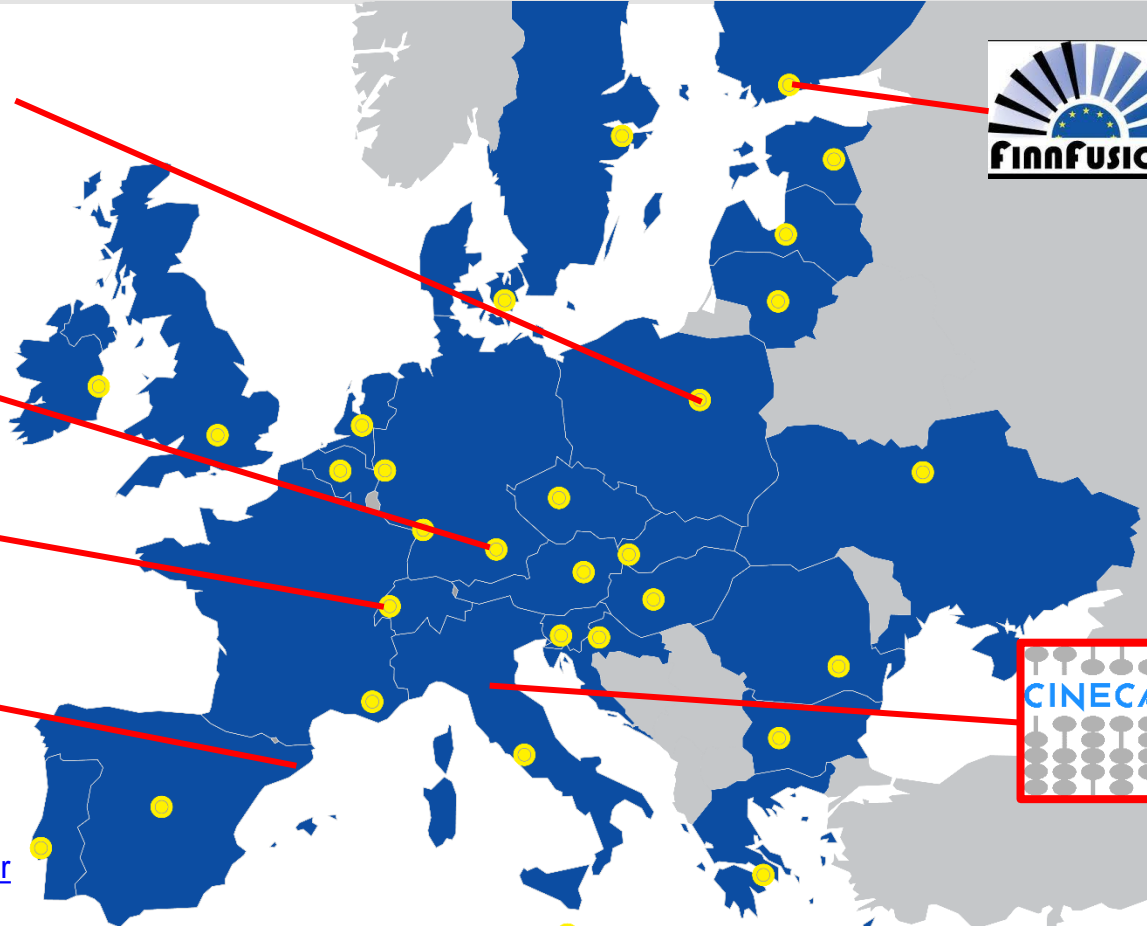


OLMAT
Madrid
Spain



GyM
Milano
Italy

EUROfusion integrates Theory and Simulation activities



5 Advanced Computing Hubs
+ [Marconi-Fusion High Performance Computer](#)

Technology transfer to industry for wider knowledge transfer



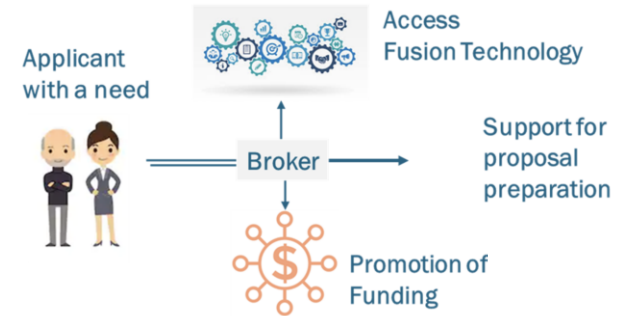
The EUROfusion Technology Transfer activities are implemented through a Consortium of Brokers (<http://techtransfer.euro-fusion.eu/>) with the aim to facilitate the **transfer of know-how to industry** with proven:

- Methodology and Tools and strong interface with non-Fusion Industry;
- Understanding of Challenges of the Fusion Market

Main Objectives and Key Performance Indicators are

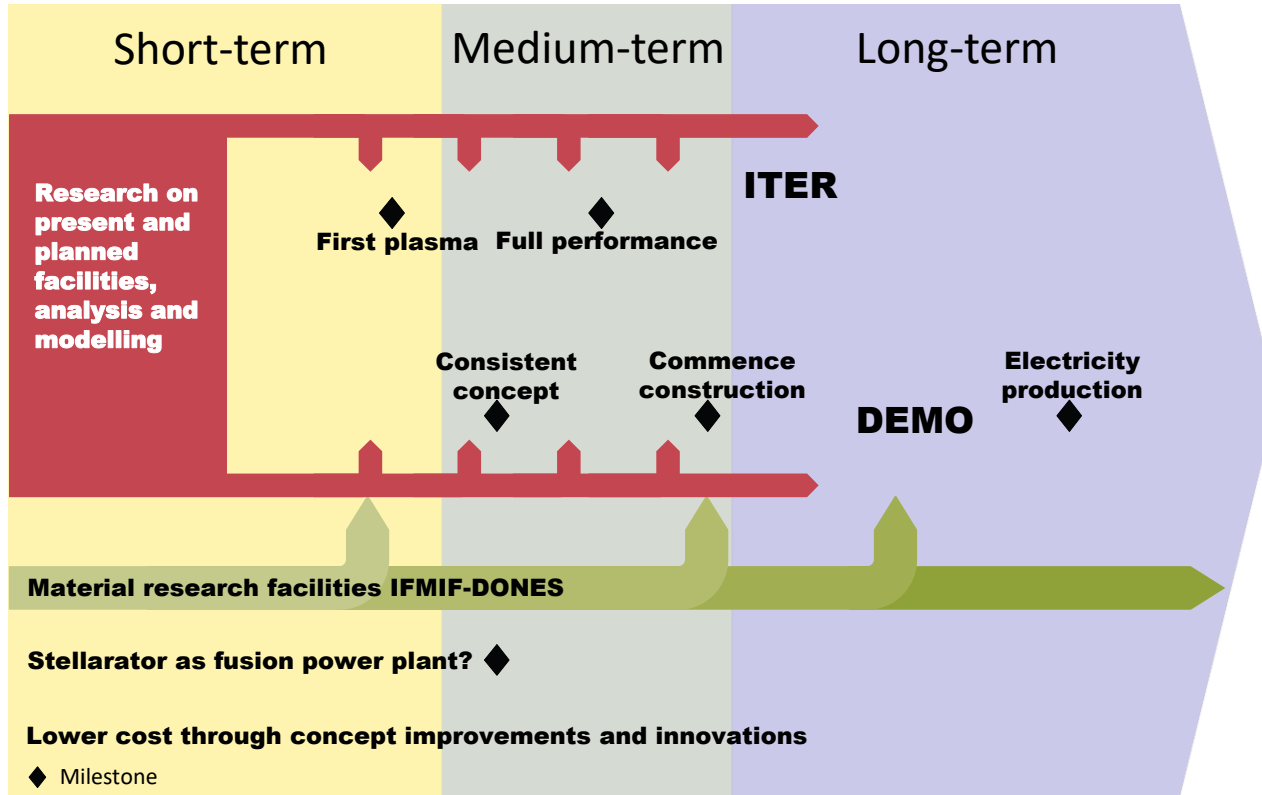
- Technology Transfers;
- Technology Descriptions for Spin-Out (Market Push);
- Technology Needs from non-fusion companies (Market Pull);
- Inputs for Success Stories Writing (filled template from brokers);
- Success Stories for publication on EUROfusion Website and Organization of non-fusion events.

[Open Call for Demonstrators](#) to develop and test EUROfusion-based technologies or know-hows for non-fusion applications in order to further stimulate innovation.



Brokers
Extenso Innovation Croissance (consortium leader) - France
RINA Consulting – Italy & Greece
Eura AG, CESAH – Germany & Austria
KIM – Spain & Portugal
Verhaert – Belgium & Netherlands

Research is prioritised along the Fusion Roadmap



DEMO = DEMOnstrator reactor, a first prototype delivering net electricity.

Roadmap Missions:

- 1) Plasma Regimes of Operation
- 2) Heat Exhaust Systems
- 3) Develop Neutron resilient materials
- 4) Ensure tritium self-sufficiency
- 5) Implementation of the intrinsic safety features of fusion
- 6) Conceptual DEMO design
- 7) Competitive cost of electricity
- 8) Stellarators

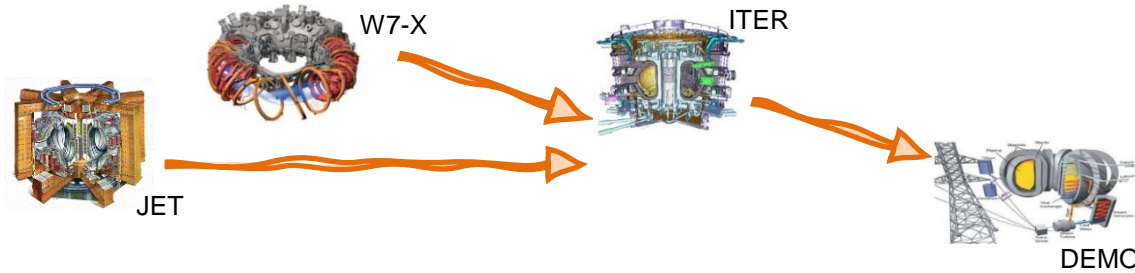
Fusion Power Plants

Download it here:



<https://www.euro-fusion.org/eurofusion/roadmap/>

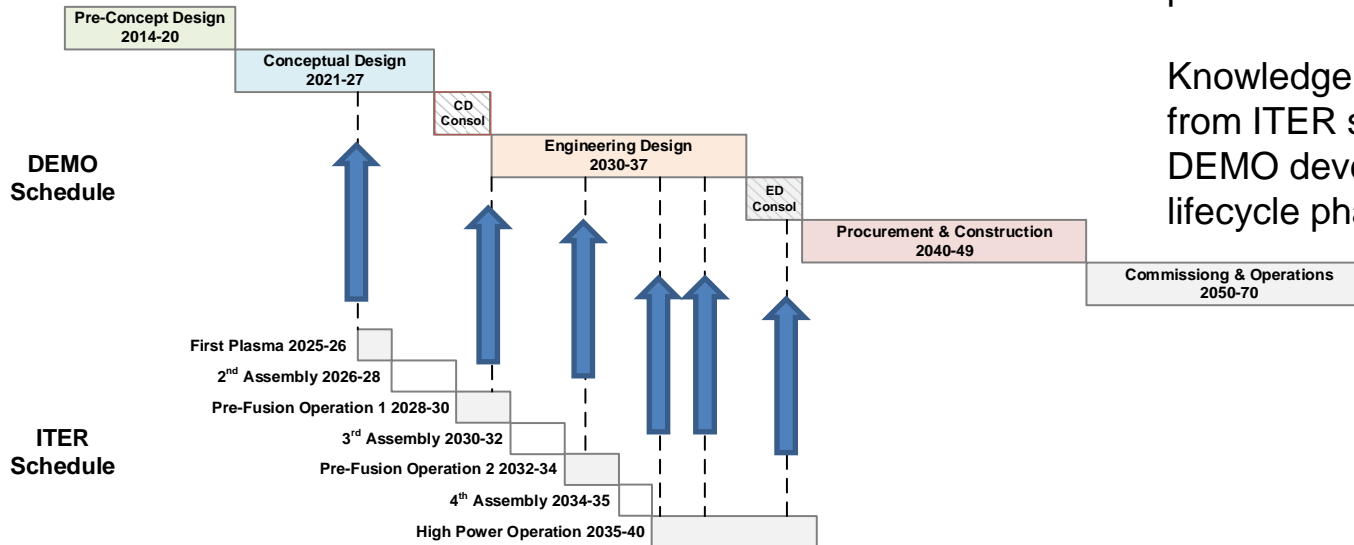
European fusion R&D feeds into next machines



Fusion R&D from 20th century feeds into next machines.

EUROfusion develops concepts for DEMO: a first net electricity fusion plant.

Knowledge and experience gained from ITER should be fed into DEMO development during various lifecycle phases.



bottom image: [G. Federici et al 2019 Nucl. Fusion 59 066013](#)

The EUROfusion programme is organised in work packages

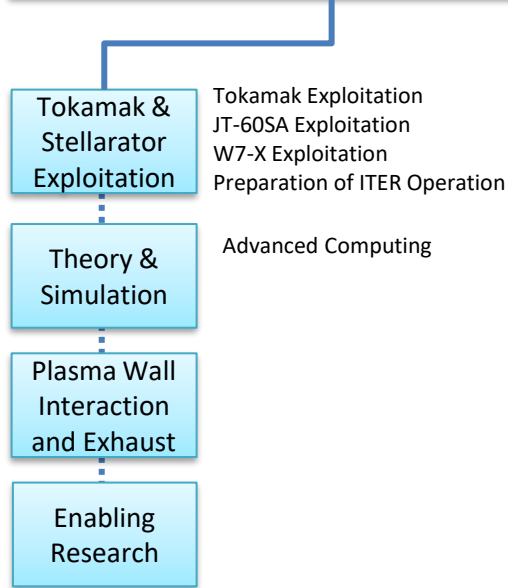


EUROfusion Programme
Programme Management Unit incl support offices:

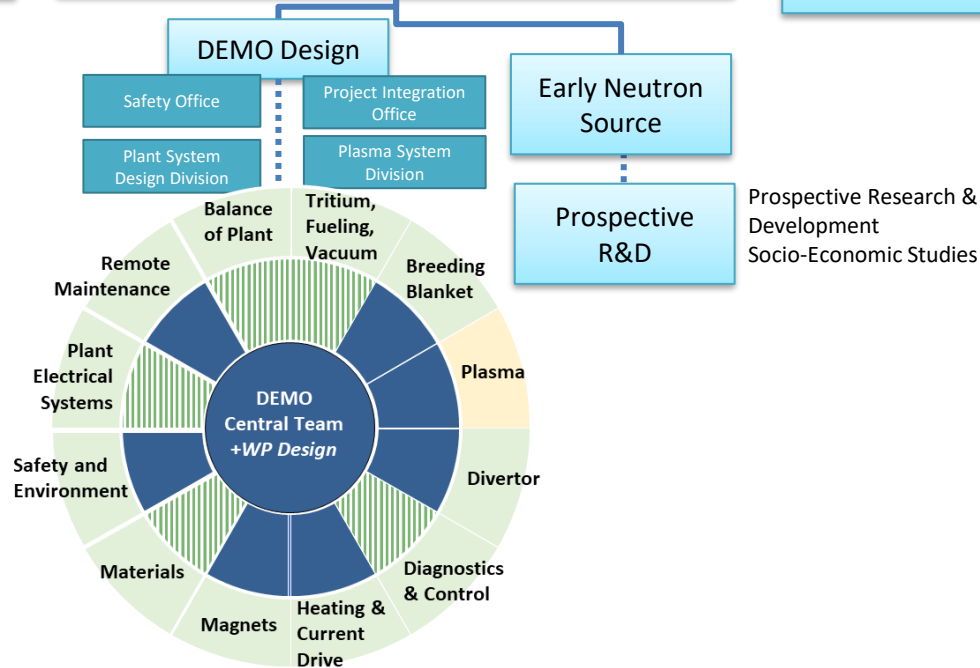
Tony Donné

International Collab.
 Publications
 Training, Education, KM
 QA Schedule
 IT / Communication

Volker Naulin (Sara Moradi)
Fusion Science Department



Gianfranco Federici
Fusion Technology Department



Emilia Genangeli
Administration

Fusion in Europe requires a long-term competence strategy

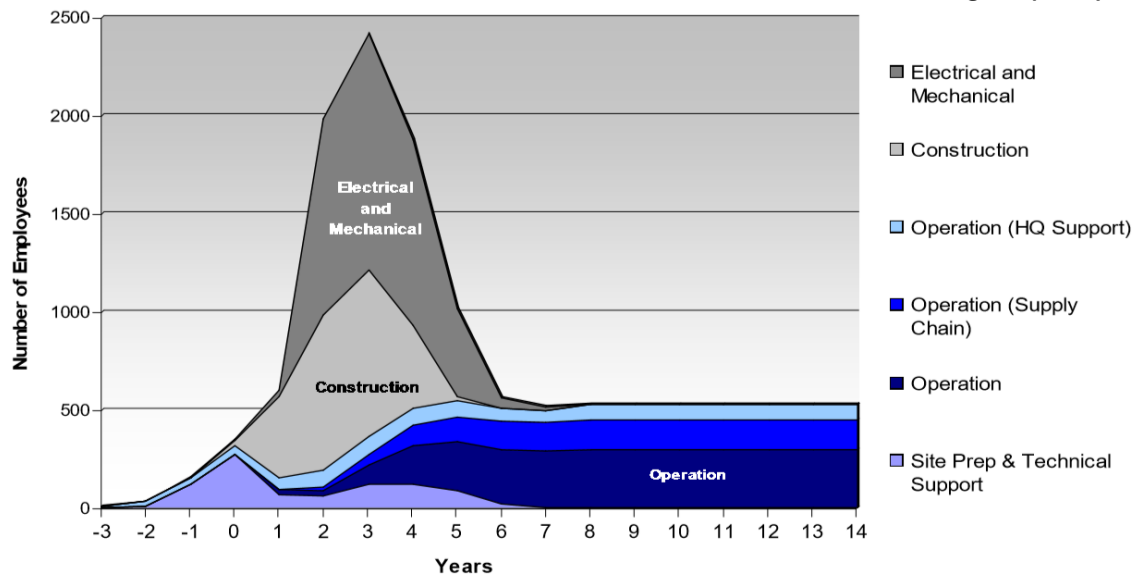


Nuclear workforce assessments are developed by several nuclear stakeholders (industry, states, policy research).

Well-known example: the assessments by EHRO-N (European Human Resource Observatory for the Nuclear Sector), coordinated by EU Joint Research Centre (JRC).

See: https://joint-research-centre.ec.europa.eu/ehro-n_en

*Example: workforce model for a single-unit nuclear power station
Clive Smith, Cogent (2011)*



For fusion also other specialisms required

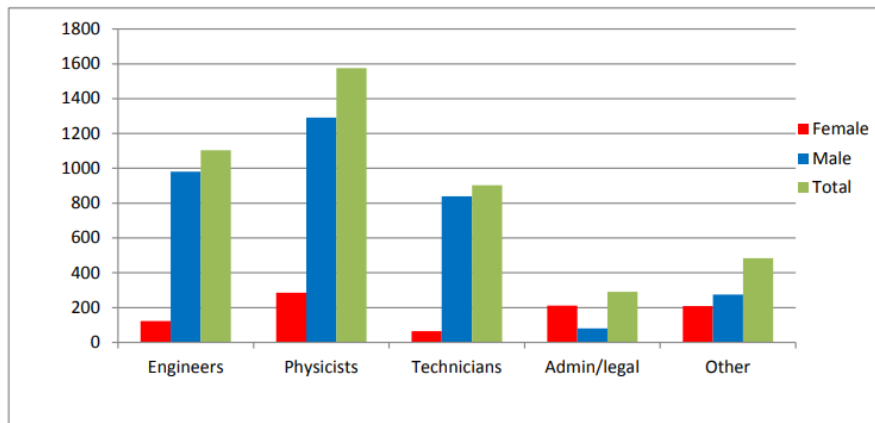
→ vacuum, magnets, heating, fuelling, diagnostics, control, plasma physics...

Therefore wider gap assessments needed (+linked to education)

EUROfusion reviews its current workforce via HR Surveys



Previous HR surveys (2004, 2015) provided insights on competences *and* diversity



Overview of the composition of personnel in the EU fusion programme (2015)

Next survey planned 2022-2023

→ Evaluate how status improved (*actions: see next*)

→ Intention to involve ITER Organization and Fusion For Energy

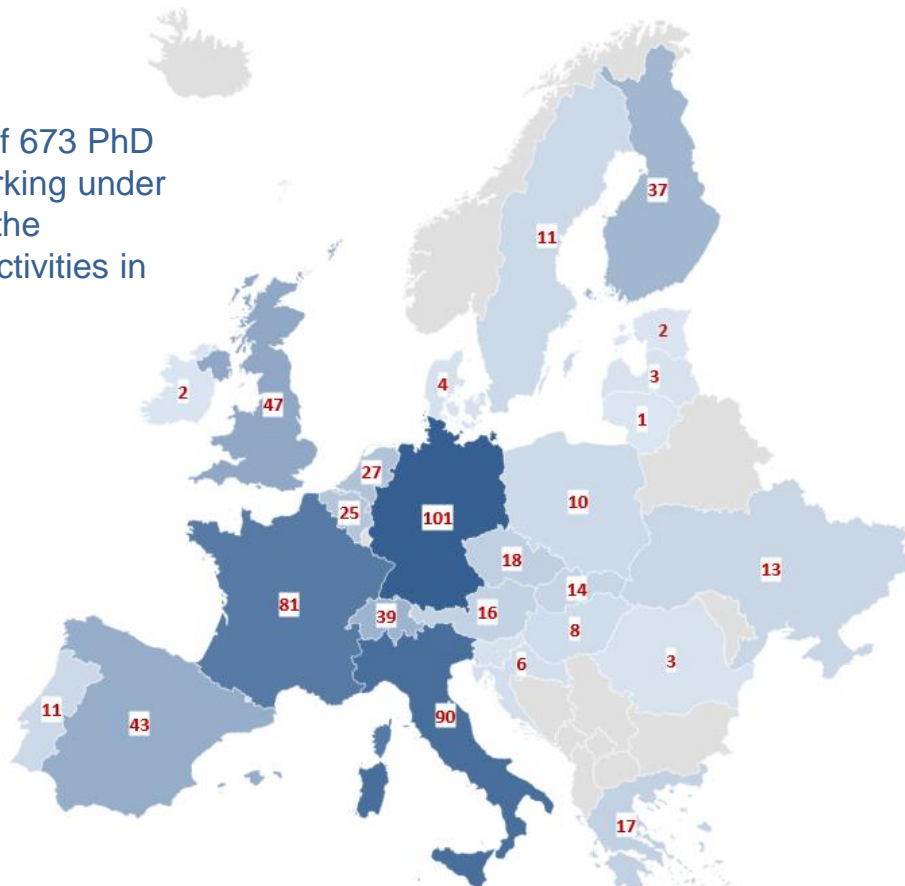
Job description	2004	2015	Change %
Physicist computational/numerical	139.30	137.32	-1.4
Physicist experimental plasma	423.45	417.03	-1.5
Physicist H&CD	84.95	48.95	-42.4
Physicist instrumentation and diagnostics	136.85	133.13	-2.7
Physicist other	137.65	224.83	63.3
Physicist theoretical analytical	227.65	133.50	-41.4
Engineer Chemical	14.40	24.09	67.3
Engineer Civil/Mechanical	59.50	65.20	9.6
Engineer computer hardware	8.00	7.90	-1.2
Engineer computer software	68.70	49.95	-27.3
Engineer cryogenic/vacuum	22.90	24.90	8.7
Engineer Design	86.20	178.63	107.2
Engineer EHV	62.00	29.30	-52.7
Engineer ELV	19.45	39.80	104.6
Engineer instrumentation and control	89.65	67.45	-24.8
Engineer Magnet	38.55	15.40	-60.1
Engineer nuclear	28.30	30.90	9.2
Engineer remote handling	23.45	7.90	-66.3
Specialist health and safety	15.00	5.75	-61.7
Specialist Machine Systems Operations	11.80	7.00	-40.7
Specialist materials science	81.70	58.75	-28.1
Specialist Project Management	48.25	21.70	-55.0
Specialist quality assurance	6.60	5.20	-21.2
Specialist tritium process	13.20	23.05	74.6
Engineer other	62.10	77.19	24.3
Technician	7.00	28.80	311.4
Socio economics	1.30	2.05	57.7
Admin/legal	39.45	67.77	71.8

Table 6: Distribution of PPy's among different specialisations and relative change between 2004 and 2015

EUROfusion bridges the HR gap via training and education



Distribution of 673 PhD students, working under the frame of the consortium activities in 2021.



Strong and versatile academic education programme and increasingly stimulating engineering.

~200 Master students

~700 Doctoral students

~60 Engineering grantees

~30 Researcher grantees

EUROfusion coordinates and contracts [FuseNet](#) (the European Fusion Education Network), implementing actions/funding for PhD, Master and younger levels.

FuseNet also collaborates and has an MoU with ENEN (the European Nuclear Education Network)

→ synergies in education

Engineering Joint Training Programme – started in 2022

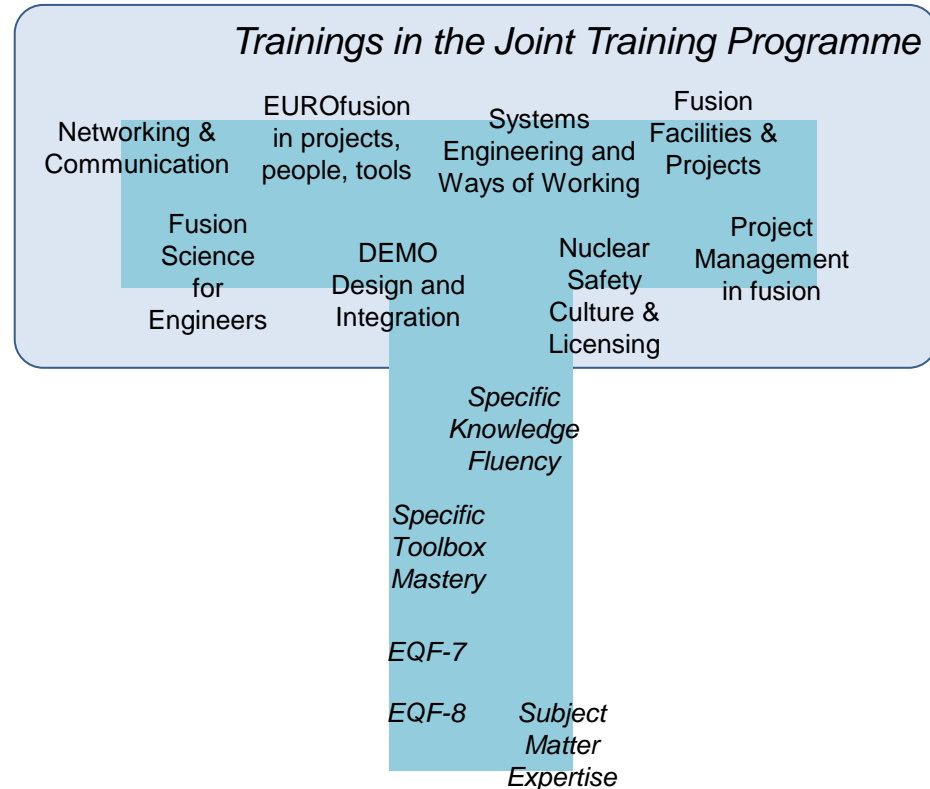


EUROfusion Engineering Grantees participate in a Joint Training Programme (started in 2022).

Competences from specialised to versatile:

- deep domain knowledge in project field; developed by Individual Training Programme
- common knowledge and skills relevant for fusion engineering career.

The Joint Training Programme, started in 2022, aims to build **competence development** and stimulate **network building**, among peers, projects, external stakeholders (including ITER Organization and F4E).



EQF= European Qualification Framework, see: <https://europa.eu/europass/en/description-eight-efq-levels>



To honour the significant contribution of Bernard Bigot to the European and international fusion endeavour (in particular ITER), EUROfusion renames its EUROfusion Researcher Grant scheme:

EUROfusion Bernard Bigot Researcher Grants

The call for the ten 2023 grants will be launched soon.

The [EUROfusion Operations Network \(EON\)](#) organises workshops, seminars and training on **operations and commissioning** to strengthen connection between operational teams

- share experience to improve reliability and performance
- improve fault identification and resolution
- identify opportunities for joint studies and exchange of equipment
- support operator training
- create a joint knowledge base
- contribute to ITER Commissioning & Operations

Contact information:

Eva Belonohy (EON Chair) Eva.Belonohy@ukaea.uk

Have a question related to Operation



Question

1. What do I know?

-> Seminars, workshops, training to increase exposure



2. Who do I know who knows?

-> Support network building through events, expert/publication/reference database



3. Reference material?

-> Create knowledge maps and knowledge base, Collate operational documents and training material, create additional reference material



Found potential solution and/or people to discuss it with



Solution

Started with wide involvement already.

(backup slide for later read:)

1st subnetwork: Monthly 2-hour remote NBI seminar series (started in May 2022)

- Joined the positive and negative neutral beam injection (NBI) communities in Europe and Japan (physicists, engineers, technicians, students, ...) + invited external experts from ITER Organisation, NIFS (LHD device) and GA (DIII-D device)
- Discussion-centered. Record and minute events, subtitles in different languages.
- Bottom-up approach in participation, presenting and proposal of topics.

Aims: build an NBI community, learn, consult, collaborate, support recruitment, joint studies

Planned activities in 2022:

- **Workshops:** vacuum conditioning, maintenance of old equipment
- **Training:** machine-independent foundation course on session leading (physics pilot) introducing the basics of operation of tokamak devices.
- **Study:** use of machine learning and AI to improve preparation and execution of operational sessions (including discharge design and analysis, fault identification and recovery)

Teams involved

JET and MAST-U

JT-60SA (Japan)

ASDEX Upgrade,
Wendelstein 7-X,
ELISE, BATMAN-Upgrade

SPIDER, MITICA

TCV

TJ-II

COMPASS-U

By Invitation

ITER

LHD

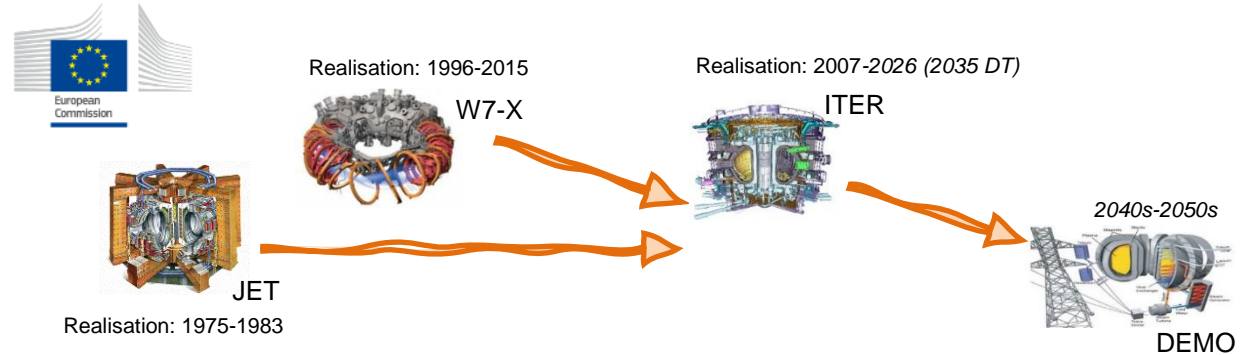
DIII-D

Know-how in European Fusion R&D is managed since 1970s



Timeline of large devices in Europe

Which brought data, experience, skills, know-how, learnings, designs, ... Europe has a vast wealth of knowledge, relevant to Horizon Europe and future framework programmes which therefore requires to be captured, transferred and preserved



- EUROfusion labs and (retired) staff have developed vast experience
 - In magnet engineering, operations, commissioning, plasma physics, diagnostics, ...
- European industry invested in ITER (procured via F4E)
- Much is transferred through publications, conferences, training, seminars, ...
- Now broader Knowledge Management systems (and resource) are needed
 - to capture, transfer and preserve know-how to mid-century (and beyond)
 - *Knowledge Management experience and advice welcome*
- EUROfusion started KM: 1st workshop (2021) + small pilots (need to build up)
 - Strategy development ongoing (activity this year)



- EUROfusion addresses all R&D challenges towards fusion power plants
- Member labs do far-reaching experimental, modelling and engineering work
- Europe-funded Training and Education coordinated
- Human Resources review will be repeated to inform HR action plans
- Knowledge Management strategy in development for FP9 and beyond
- Exchange on this with experienced (nuclear) partners welcome



Press release: [EUROfusion launches into new era of research signs Grant Agreement - December 2021](#)

EUROFUSION HUMAN RESOURCES DEVELOPMENT, TRAINING AND KNOWLEDGE MANAGEMENT: NEXT STEPS TO BRINGING THE FUSION RESEARCH COMMUNITY TO THE NUCLEAR NEWBUILD ERA

A.G.G. LANGE¹, J. HOLDEN^{1,3}, F. VINAGRE¹, S. MORADI¹, E. BELONHOY^{2,3}, G. FEDERICI¹, V. NAULIN¹, A.J.H. DONNÉ¹

Email contact of corresponding author: guido.lange@euro-fusion.org



Efficient and effective Human Resource Development (HRD) and Knowledge Management (KM) policies are imperative to the successful implementation of the long-term vision of the European Fusion Research programme, which is outlined in the EUROfusion Roadmap [1]. EUROfusion is a consortium of 30 research institutes across the European Union, the UK, Switzerland and Ukraine, with 152 affiliated entities, including universities. Together they implement Euratom's nuclear fusion research programme. The main objectives are to prepare for ITER exploitation and to develop concepts for a DEMO fusion electricity plant.

ITER is the first nuclear facility in fusion and currently in assembly phase. With DEMO currently in the conceptual design phase, periods of up to about twenty years may be between similar project phases. Thus, effectively capturing, transferring and preserving the know-how and experience is critical to the success of the future programme. In this aspect, fusion can learn from the experience in fission. As the full lifecycle of a nuclear power plant spans multiple career lengths, it is understandable why systematic knowledge transfer and preservation activities are well-established in the fission community and why it is a safety requirement for power plants.

The European fusion research programme bears a vast amount of know-how that spans from fundamental physics research to (remote) maintenance concepts, from plasma-wall interaction to tritium fuel cycle, and other systems. Also, within the EUROfusion member institutes, an extensive experience in the operation and commissioning of experimental fusion devices exists, such as tokamaks JET, ASDEX-Upgrade, MAST-Upgrade, TCV, and WEST, stellarators like W7-X, and several smaller experiments. The success of future projects, such as ITER, will rely on the experimental and operational know-how that has been developed in the current devices. Moreover, the success of further technology development, such as for DEMO, benefits from the experience in conceptual design activities in the projects as NET (Next European Torus) and ITER in the past decades.

This paper introduces a series of observations and pilot activities with the purpose to build a comprehensive and coordinated Human Resource Development and Knowledge Management programme. Within the IAEA Technical Meeting Fission-Fusion Synergies, this has the intention to identify synergies for collaboration, invite suggestions and learn from best practices from various stakeholders in the nuclear community. From research to industry to regulator, many should gradually become more involved in future fusion projects.

Education, Training and Human Resources Development

EUROfusion provides support for close to 700 PhD students and coordination of academic education programmes in the field of nuclear fusion. In addition, every year EUROfusion supports 15 early career engineers in the form of a 3-year EUROfusion Engineering Grant (EEG) and 10 early career scientists in the form of 2-year EUROfusion Research Grants (ERG). The ERG is a postdoc scheme in which proposals to open research problems are evaluated based on excellence. The EEG topics mainly target engineering and technology challenges of the highest priority and/or scarce competences where the community needs more experts in the near future. A joint training programme has been established in 2022 to provide further training to candidates on various soft skills and generic knowledge as well as supporting building their network.

EUROfusion is in close collaboration with the European Fusion Education Network (FuseNet), an association with the purpose to stimulate and disseminate fusion education across Europe. Coordinated by EUROfusion, FuseNet implements various activities, including internship support for MSc students, an annual PhD Event, a Teacher Day for secondary school teachers, coordination and organisation of advanced Master workshops and the maintenance and presentation of an education material repository [2].

In 2022-2023, a Human Resource Survey will be conducted in the EUROfusion community, following a previous assessment done in 2016. The objective is to gauge the current skills and human resource status and, together with the assessment of workforce needs in the years ahead, the development of a competence strategy. In the assessment of industry, collaboration is sought with Fusion for Energy, the European Joint Undertaking for ITER and the Development of Fusion Energy, acting as European procurement agency for ITER. The survey will be discussed in a dedicated workshop in 2023 focusing as well on the current training and Human Resource practices and needs within the EUROfusion community.

Knowledge management

By its nature of a longstanding R&D programme, knowledge transfer and preservation activities already exist, in various forms. This includes conferences, publications, seminars, training activities within institutes. However, the risk of losing specialised competences is deemed high, in this high-tech research field with long development timelines. Therefore, more coordinated measures are required.

To remedy the loss risks, EUROfusion has chosen to devote more attention to a programmatic KM strategy in the recently started framework programme Horizon Europe. To raise awareness on the topic and collect needs for the KM activities, workshops are being organised with internal and external stakeholders. An additional survey among workshop participants was conducted to provide an overview of the knowledge management needs and gaps of EUROfusion. There is consensus on the importance of the topic and the need to mitigate loss of critical competences. Priority was given to the mapping, traceability and accessibility of project documentation.

Acknowledging that the fission community has longer experience with knowledge management and systematic human resource development, it is the intention of the contributors to establish collaborations in various technological areas of shared interest, such as materials, waste technology, molten salts, tritium fuel cycle and deuterium technology, remote handling, control and diagnostics, design safety and safety analysis, project management, supply chain, operation and training.

Knowledge Management pilot activities

Several pilot projects have started or are in preparation, with the objective to form building blocks of an overall strategy. The objective is to grow these activities steadily. They are briefly introduced here.

—A pilot with the collaborative platform MS365 has been started, allowing several teams from various associations and EUROfusion work packages to work collectively (share and edit document, improved communication). The goal is to make use of the additional collaborative features, which the current document management system does not provide. Within the DEMO design activity, a start will be made with a Product Lifecycle Management (PLM) system to manage the conceptual design baseline documentation;

—A mapping of the status, location and access of relevant knowledge is in development within several EUROfusion work packages and around the recent deuterium-tritium campaign of the JET tokamak. A lessons-learned database is in preparation with the template and process in a pilot phase, to capture relevant experience systematically;

—On the Garching campus in Germany, where the EUROfusion Programme Management Unit resides, physical archives are stored of technical work dating back to the 1980s, e.g., NET (Next European Torus), ITER Conceptual Design Activity, The SEAFP Project (Safety and Environmental Assessment of Fusion Power). There is interest in that a relevant selection of these documents is preserved, digitised and their contents become searchable. Currently steps are taken to preselect and classify, such that a mass digitisation activity can take place later in 2022;

—Finally, the EUROfusion Operations Network (EON) was established in 2021 to connect the operational experts across the EUROfusion facilities to share their operational know-how and experience. The EON network is organising, starting from 2022, seminars, workshops and training on various topics related to the operation of fusion devices such as tokamaks and stellarators.

Outlook and collaborations

The EUROfusion activities in Human Resource Development and Knowledge Management aim to develop a strong and consistent strategy that ensures the capability of Europe to make future phases of ITER and DEMO successful. In this way, EUROfusion actively cooperates with the ITER Organization and its European implementation agency, Fusion for Energy (F4E). EUROfusion develops cooperation on KM with F4E, which also organises internal KM activities. By exchanging best practices and joining forces in (technical) areas of common interest, the joint aim is to preserve the relevant know-how in the European programme. The Broader Approach Agreement (between the European Union and Japan) is a notable successful collaboration activity. EUROfusion further aims to seek collaboration with other stakeholders in the nuclear field such as IAEA of which its strong track record in assessments, policy advice and programme development in the nuclear sector, are deemed valuable to the human resource development and knowledge management needs in the nuclear fusion endeavour.

REFERENCES

- [1] DONNÉ, A.J.H. et al., (2018) "European Roadmap to the Realisation of Fusion Electricity", EUROfusion, ISBN 978-3-00-061152-0, available at <https://www.euro-fusion.org/eurofusion/roadmap/>
- [2] FuseNet, Fusion Education Material Browser, see: <https://fusenet.eu/education/material>